Childhood Lead Poisoning: The Potential and Pitfalls of Applying GIS to the Development of Federal Environmental Justice Policy

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Abstract

Childhood lead poisoning is the most common environmental illness facing US children. When the first federal legislation passed in 1971, children in communities of color and low-income communities were disproportionately at risk, a characteristic typical of communities organizing around environmental justice principles. Efforts since then have decreased the extent of childhood lead poisoning, but have increased the disparate impact of the disease. Since the 1994 passage of Executive Order 12898 on environmental justice, the US Environmental Protection Agency (EPA) has begun to develop geographic information system (GIS) programs to assess a broad array of environmental justice issues. This paper will describe the origin of the environmental justice movement and examine childhood lead poisoning as an environmental justice challenge. It will then outline three GIS approaches to childhood lead poisoning and consider what the strengths and weaknesses of those approaches portend not only for EPA's efforts to prevent childhood lead poisoning in the Southwest, but for other GIS uses designed to remedy environmental justice problems.

Keywords: lead poisoning, environmental justice, race, class, public health

Introduction

Potential, and pitfalls, abound in the use of geographic information systems (GIS) to identify and solve public health problems. Childhood lead poisoning is a particularly sensitive example given the role this illness has played in federal recognition of a social movement called environmental justice. The goal of this paper is to relate environmental justice, federal policy, childhood lead poisoning, and GIS in a cautionary tale that recognizes how GIS can promote or stifle positive social change. This paper will describe the origin of the environmental justice movement and examine childhood lead poisoning as an environmental justice challenge. It will then outline three GIS approaches to childhood lead poisoning and consider what the strengths and weaknesses of those approaches portend not only for the US Environmental Protection Agency's (EPA's) efforts to prevent childhood lead poisoning in the Southwest, but for other GIS uses designed to remedy environmental justice problems.

Genesis of the Environmental Justice Movement

Extensive histories have been written about the environmental justice movement (1,2). However, a few key incidents defined the movement for the federal government.

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Low-income communities of color created the environmental justice movement in recognition of the small share of environmental amenities and large share of environmental burdens they experience. Such burdens range from a disproportionate rate of environmental disease to the disproportionately high concentration of toxic waste facilities sited in their communities. Indeed, it was during the release of the 1987 GIS study Toxic Waste and Race (3), identifying the disproportionate siting of toxic waste facilities in low-income communities of color, that the term "environmental racism" first achieved national prominence.

More than 100 environmental justice groups came together in Washington, DC, in 1991 at the First National People of Color Environmental Leadership Summit to create the "Principles of Environmental Justice." These 17 principles represent the consensus understanding of these groups and guide their approach to the challenge of unequal protection.

Within a year after the summit, EPA issued its first report on the matter (4). That report identified childhood lead poisoning as the only environmental illness disproportionately harming low-income communities and communities of color. As more research was conducted, however, and the scope of the problem beyond childhood lead poisoning became apparent, greater federal involvement became necessary.

In 1994, hundreds of federal officials and activists from environmental justice groups came together at the Symposium for Health Research and Needs to Ensure Environmental Justice to discuss the issue. During the symposium, President Clinton signed an executive order on environmental justice that required federal agencies to develop strategies to address environmental justice concerns and established a federal advisory committee that would provide a regular forum for environmental justice issues to be raised (5). Since then, the National Environmental Justice Advisory Council has met every six months in communities around the country, and dozens of federal agencies have developed environmental justice strategies (6).

Lead Poisoning as an Environmental Justice Challenge

Childhood lead poisoning is the most common environmental disease threatening US children. When the first federal lead poisoning prevention legislation passed in 1971, children in communities of color and low-income communities were recognized as being at high risk for the condition. Efforts since then have dramatically decreased the extent of childhood lead poisoning, but have failed to diminish the disparate impact of the disease. And, in fact, the disparity has grown.

Between 1976 and 1994, the percentage of children with elevated blood lead levels (above 10 micrograms per deciliter [μg/dL]) from the highest income bracket decreased at a rate seven times greater than the percentage of children with elevated blood lead levels from the lowest income bracket. A similar analysis by race indicates that the percentage of white children with elevated blood lead levels declined at a rate four times greater than that of their black counterparts. The benefit of "whiteness" is explicit as Hispanic children are twice as likely, and black children fives times more likely, to have elevated blood lead levels than are white children. As a result, the number of black children with elevated blood lead levels is equal to the number of white and Hispanic children with elevated blood lead levels. Before discussing the implications of these findings, consider how GIS fits in the picture.

Three GIS Approaches to Childhood Lead Poisoning

Childhood lead poisoning occurs as a consequence of lead exposure. In the past, targeting efforts to control childhood lead poisoning followed the "canary in the coal mine" model. That is, after a child was poisoned, health professionals would seek to identify and eliminate the source of lead exposure. GIS offers the opportunity to take a more proactive approach by mapping out risk factors and identifying communities at risk for lead exposure.

The risk factors for assessing children's lead exposure identified by the Centers for Disease Control and Prevention (CDC) include:

- Pre-1950 housing
- Demographic factors
- Industrial sources and parental occupation
- Drinking water
- Hobbies, traditional remedies, ceramicware, and cosmetics (7)

Using GIS to overlay maps of these various risk factors can help EPA childhood lead poisoning prevention personnel determine where greatest needs exist, what type of resources should be allocated, and success over time. The following three different GIS approaches have been developed to support childhood lead poisoning prevention efforts.

The first GIS application that focused on childhood lead poisoning prevention was described in 1991. Researchers at the New Jersey Department of Environmental Protection and Energy and the University of Medicine and Dentistry of New Jersey used GIS to identify areas within Newark, East Orange, and Irvington, New Jersey, where there may be greater environmental exposure to lead. The purpose of the study was to identify areas where further screening and public education may be needed (8).

Table 1 lists the sources of data used in this 1991 study. Data incorporated into the GIS included US Census Bureau demographic and boundary data. Furthermore, data that reflected point industrial and urban corridor sources of lead, as well as blood lead screening records, were included. The strength of the application was reflected in the finding that a strong correlation existed between census tracts with reported high blood lead levels and census tracts predicted by the GIS to support high lead exposure.

In 1992, the Lead Education and Abatement Program (LEAP) in EPA's Region 5 office published its GIS assessment of the spatial and numerical dimensions of young minority children exposed to low-level environmental sources of lead (9). This study of the Great Lakes area did two things. First, it developed a population comparative risk analysis for childhood exposure to lead in census tracts in 83 Midwest cities. Second, it examined whether there was an association in the Minneapolis/St. Paul area between urban transportation corridors and elevated blood-lead levels.

Table 2 lists the data sources used in this 1992 population comparative risk analysis. The study used Census Bureau boundary data. Because the 1990 census data had still not been released, the researchers used the Donnelly Marketing Population database for demographic data extrapolated from 1980 to 1990. Point industrial, urban corridor, and drinking water sources of lead were included.

The study found a statistically weak association between Minneapolis/St.Paul urban corridors and blood lead levels. Furthermore, a weak association was identified

Table 1 Databases Used in 1991 GIS Study of Lead Exposure in Newark, East Orange, and Irvington, NJ

Database	Source
Census tract boundaries, demographics, and housing stock	US Census Bureau
Essex County blood lead screening records	New Jersey Department of Health
Toxic Release Inventory of industrial sites emitting lead	US EPA
Hazardous waste sites contaminated with lead	New Jersey Department of Environmental Protection and Energy
Traffic volume estimates to determine past leaded fuel emissions	New Jersey Department of Transportation

Table 2 Databases Used in 1992 GIS Study of Lead Exposure in the Midwest (with detailed analysis in Minnesota)

Database Source	
Ambient air quality data	Aerometric Information Retrieval System
Ethnicity, sex, age, income, housing age, and location	US Census Bureau; extrapolations available via Donnelly Marketing Population Data
Surface meteorological data	National Climatologic Data Center
Toxic Release Inventory for point sources of lead emissions and facilities that dispose of lead	US EPA
Municipal waste incinerators emitting lead	US EPA
Lead levels in drinking water	US EPA
Abandoned hazardous waste sites where lead is a primary concern	US EPA
Lead concentrations in soil and dust	US Department of Housing and Urban Development; Minnesota Department of Pollution Control
Blood lead screening data	Minnesota Department of Health

between the blood lead levels predicted by the GIS and those measured through screening efforts. The researchers attributed the weak association to the fact that the model is applicable to populations, not individuals, and that an inability to account for ethnicity and socioeconomic status resulted in an underestimate of the at-risk population in lower socioeconomic minority communities. The researchers concluded that the effort should prove useful in identifying hotspots of lead exposure.

The year 1993 witnessed the first results of the EPA Office of Pollution Prevention and Toxics Lead Targeting System, a meeting in Atlanta titled "Mapping Lead Exposure Information" by the EPA Environmental Criteria and Assessment Office, and the release of information about efforts to use GIS to target childhood lead poisoning prevention activities in California and Massachusetts. Unfortunately, this brief flurry of activity did not prove sustainable. The challenge, as summarized by a co-author of the 1991 New Jersey study, was

> . . . to better understand the complexities of lead exposure and vulnerable populations. This effort requires addressing the issues of what information should

be collected, of how to best collect information, how to overcome incompatibility of data, and ways to share information between different software packages and hardware (10).

In 1998, many of those challenges remain. However, the question of what information should be collected has been somewhat simplified. For example, EPA Region 3 is currently using GIS to help identify the human health risk from lead and, in particular, reduce the prevalence of childhood lead poisoning in targeted communities (11). They are doing so by assessing the lead poisoning risk factors mentioned previously and eliminating those factors less often causally related to childhood lead poisoning. They have selected age of housing, poverty, and the presence of children as the focus of their analysis. These researchers are using Census Bureau boundary and demographic data, and US Department of Housing and Urban Development (HUD) housing data in their review. Table 3 identifies additional sources of data used in this study.

Table 3 Databases Used in the 1998 GIS Study of Lead Exposure in Mid-Atlantic States (with detailed analysis in Philadelphia)

Database	Source
Affordable housing	US Department of Housing and Urban Development
Age, income, owner-occupied vs. renter-occupied housing, and housing age	US Census Bureau
Residential lead hazard	US Department of Housing and Urban Development
Blood-lead screening data	Philadelphia Department of Health

The Region 3 study found that targeting major urban areas would, if fully successful, address only 25% of the houses estimated to have lead-based paint, 8% of houses expected to have lead-based paint hazards, and 33% of the children in poverty. In response, Region 3 is beginning to implement a children's initiative that will target lead exposure risks to children in smaller urban areas.

The weakness of this approach is that it does not consider causes of childhood lead poisoning that, while less prevalent, may be significant. That challenge confronts those of us working in Region 9 as we try to develop plans to decrease childhood lead poisoning.

Current Challenges

Region 9's 1993 effort to create a GIS application to measure the potential for elevated blood-lead levels used Census Bureau demographic data to localize childhood lead poisoning in Oakland, California, and the surrounding areas of Alameda County (12). In that one county alone, EPA researchers found thousands of white, black, Hispanic, Asian-American, and other ethnicity children living in poverty. More than 80% of homes were coated with lead-based paint. Potential sources such as water and industrial emissions were considered. And what did they find? A mess that could not be readily sorted out for targeting purposes and that did not closely match the results of screening data that were being collected in the area.

This is not a surprise. Communities in the Southwest are substantially different from those in the Northeast and Midwest. Some of the challenges of preventing childhood lead poisoning in the Southwest (compared with the Midwest or the Northeast) include the following:

- **Space:** Housing is diffuse so hot spots are more difficult to identify and target for action.
- **Time:** Rapid population growth in the Southwest results in data rapidly becoming obsolete.
- **Population:**
  More diverse and more integrated.
  Cultural exposure sources more prevalent.
  Modeling spatial dimension of ethnicity more difficult.
  Class component of childhood lead poisoning weaker.
  Population at greatest risk more likely to speak English as a second language.
- **Medical practice:** Pediatricians are less aware of childhood lead poisoning and less likely to screen.
- **Legislation:** Non-existent or very recently passed.
- **Government agencies:** Relatively recently recognized problem with limited and very localized data to guide action.

Housing stock is more spread out in the Southwest than in the Northeast. Thus, the potential for spatial autocorrelation (which is quite high in densely populated cities of the Northeast) is diminished. Race and class are also much less effective predictors of childhood lead poisoning. The population of California is a bit more than 50% white, 30% Hispanic, 7% black, and 6% Asian-American. Communities in the Southwest are more racially integrated and class does not have as strong an influence upon the prevalence of lead poisoning. Furthermore, cultural characteristics may promote childhood lead poisoning in the Southwest more than in the Northeast, because the Hispanic and Asian populations are more likely to use folk medicines, ceramicware, and cosmetics that contain lead.

For example, a study released by the General Accounting Office in May 1998 noted that the California Department of Health Services has reported that up to 12% of lead-poisoned children in the state may have been poisoned from traditional folk medicines and another 8% of cases may have been linked to lead-glazed pottery, often from Mexico (13). The same report also noted that while Hispanic children in pre-1946 housing had a higher prevalence of elevated blood lead levels than those in newer housing, in either setting the risk of elevated blood lead levels was not appreciably changed by poverty status.

Finally, unlike many cities in the Northeast where lead screening and awareness are relatively high, little screening has taken place in the Southwest and most is quite recent in origin. Indeed, before a 1992 court decision forcing the issue, screening was rarely performed in California, even for children on MediCal. Recent studies indicate pediatricians in California continue to screen children much less often than their counterparts in other parts of the country (14,15). Thus, unlike other areas, it is difficult to analyze GIS applications for lead exposure risks relative to screening data because, until recently, little data existed and, as a result, confidentiality concerns were difficult for researchers to overcome.

As is apparent from these facts, the childhood lead poisoning situation in the Southwest is appreciably different from that in the Northeast where most GIS applications have been tested and where federal policy efforts are focused. Yet, despite these differences, it is important to note one universal truth—that children in old homes are more likely to suffer lead poisoning. California has more homes built before 1950 than any state other than New York or Pennsylvania.

Despite the challenges posed in the Southwest, two national GIS programs are being developed to identify communities at risk for childhood lead poisoning. HUD has recently released "Community 2020" (16). This program allows maps to be created instantly by selecting and displaying census data. The program targets areas by overlaying four characteristics: housing older than 1950; presence of children under six years old; minority status; and, presence of single parent household. The goal is to use this application to target inspections and compliance assistance to better implement the new real estate disclosure law for lead-based paint.

Census data are also the building block for the CDC software that has been developed to provide relevant data on housing and population to help identify high-risk areas for childhood lead poisoning screening (17). This software can be accessed over the Web and, while still in the process of being integrated with mapping, provides county and zip code level data on a broad array of factors including: housing units, pre-1950 housing, children under six years old, race, income, owner or renter status, and percent of children under six years old in poverty.

Future Moves

Both the Community 2020 and new CDC software go a long way toward incorporating the breadth of demographic data absent in some of the earlier applications. However, the need to refine our focus is reinforced by two recent targeting studies contracted by EPA. The first provided support for the notion that real estate disclosure enforcement efforts should target extremely rural areas like Tulare County, California, before targeting Los Angeles (18). The second confirmed once again that race, income, census region, and age of housing are associated with environmental lead exposure and that blood lead level variations by race and class may not be adequately explained by environmental lead measurements (19). Both studies conclude that resources should be focused on Northeast or Midwest communities, yet both fail to acknowledge differences in the epidemiology of childhood lead poisoning in the Southwest that may alter such findings.

Conclusion

Within the last year, the EPA received more than $3 million in applications for lead poisoning prevention activities from non-profit groups in Region 9, though only $200,000 in funding was available. Many of the groups applying are run by, and serve, low-income communities of color most at risk for the disease. These environmental justice groups recognize that despite the decreasing prevalence of childhood lead poisoning, the battle has not been won because their children have been left behind in past federal efforts. GIS can help federal agency personnel decide where to target limited resources for screening, grants, and enforcement in order to eliminate disparities in disease prevalence. However, if "garbage in, garbage out" GIS models are produced that fail to recognize the unique situations that different areas face, federal agency personnel not only miss an opportunity to ensure equal protection under the law for all Americans, but also perpetuate the idea that helped generate the environmental justice movement in the first place—that government agencies may not only fail to remedy vestiges of past racism and classism, but through a failure to recognize such challenges may create new barriers to creating a just and fair society.

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